Case Report

Deformation and Migration of Palmaz Stents after Placement in the Tracheobronchial Tree[1]

Sean Perini, MD
Roy L. Gordon, MD
Jeffery A. Golden, MD
Jeanne M. LaBerge, MD
Mark W. Wilson, MD
Robert K. Kerlan, Jr, MD

Index terms: Bronchi, stents and prostheses • Bronchi, stenosis or obstruction

JVIR 1999; 10:209–215

ENDOBRONCHIAL stent placement with expandable metallic stents has emerged as a potential treatment for airway narrowing resulting from a variety of benign and malignant diseases (1–8). Treatment of anastomotic strictures or airway malacia with use of metal stents following lung transplantation has been reported by a number of authors (2,4–6,9,10). Stent placement represents an appealing therapeutic option for patients with widespread malignant tumor, when long lesion length prohibits resection, in cases in which surgery is otherwise contraindicated, or when airway narrowing threatens imminent respiratory failure. For management of stenoses resulting from extrinsic compression, endobronchial stent placement represents one of few therapeutic options since treatments such as endoscopic resection (11), cryotherapy (12), or laser photoresection (13) are not possible.

Published experience with tracheobronchial Palmaz stent placement is relatively limited. The existing series report generally favorable or promising results (3,7,8). Herein, we report the deformation and collapse of expandable Palmaz stents following placement within the airways of three different patients. Migration of tracheobronchial Palmaz stents was seen in two of these patients and, to our knowledge, has not been previously reported. In one of these patients, a Palmaz stent migrated from its initial position in the left mainstem bronchus to the right lower lobe bronchus. These complications were seen in a consecutive series of tracheobronchial stent placements between November 1995 and October 1997. During this 23-month interval, 24 Palmaz stents were placed in eight patients.

Hautmann has previously reported one case of Palmaz stent collapse following placement within the tracheobronchial tree (14). An additional case was seen in a series of 12 patients reported by Slonim et al (8). The suitability of the Palmaz stent for use in the tracheobronchial tree is brought into question by the frequency of stent failure we have experienced coupled with prior reports of failure by other investigators.

METHODS

A combined team of physicians from the interventional radiology and pulmonology departments performed all endobronchial stent placements. Each of the stent placement procedures was performed during administration of general endotracheal anesthesia. Endotracheal lidocaine was administered to reduce bronchospasm. Stent and balloon diameters were selected to match or minimally exceed the diameter of adjacent normal airways. Initial measurements were obtained with use of preprocedure chest computed tomography (CT) examinations. These measurements were verified during the stent placement procedures by comparing air bronchogram and bronchoscope diameters fluoroscopically. Appropriate stent length was determined by measuring the amount of bronchoscope withdrawn or inserted to move the distal end of the instrument across the region of narrowing.

Prior to stent deployment, lesions were localized with external position markers placed using combined bronchoscopic and fluoroscopic guidance. Bronchography was not used. Initial Palmaz stent placement was performed without predilation. A guide wire was passed through the bronchoscope and across the lesion under direct visualization. The bronchoscope was then removed. The Palmaz stent

[1] From the Department of Radiology, Section of Interventional Radiology (S.P., R.L.G., J.M.L., M.W.W., R.K.K.) and the Department of Medicine, Division of Pulmonary Medicine (J.A.G.), University of California, San Francisco, Interventional Radiology, M-361, 505 Parnassus Avenue, San Francisco, CA 94143-0628. Received February 18; revision requested March 30; revision received July 14; accepted July 16. **Address correspondence to** S.P.

Table 1
Patient and Stent Placement Data

Patient No.	Age at Stent Placement (y)	Diagnosis	Initial Stent Placement Date	Stent Placement Location	Palmaz Stent Type*	Maximum Dilation Diameter (mm)
1	54	Right lung transplant 9/6/95 for severe emphysema	2/26/97 and 3/14/97	Right mainstem bronchus	P308 (3)	14
2	52	Left lung transplant 4/7/92 for severe emphysema	1/27/97	Bronchus intermedius	P308 (1)	12
				Left mainstem bronchus	P308 (2)	10
3	55	Wegener granulomatosis with increasing shortness of breath	5/8/96	Left mainstem bronchus	P154 (1)	8

* Numbers in parentheses are number of stents placed.

Table 2
Stent Failure and Intervention Data

Patient No.	Stent Failure Time (days after initial stent placement)	Stent Failure	Intervention
1	44	Partial collapse with loosening and displacement of bronchus intermedius stent	Removal of stent using tip deflecting wire; placement of two new Palmaz stents (P154, P204)
	219	Crumpled right mainstem bronchus stent	Failed attempt to remove crumpled stent; dilation of crumpled stent with 15-mm balloon; placement of coaxial 16-mm Wallstent.
2	78	Stent crushed	Coaxial placement of two additional Palmaz stents (P308)
3	211	Spontaneous migration of stent into bronchus intermedius	Finding not recognized at time of CT examination
	362	Crumpling and further displacement of the stent into right lower lobe bronchus	Crumpled stent removed using retrieval sheath and basket

was advanced over the wire and across the lesion. The stent was balloon expanded at the location delimited by the previously placed external position markers. Bronchoscopy was performed to confirm stent position and appropriate apposition of stent against airway walls. The establishment of a stented lumen comparable in diameter to the adjacent normal airway and absence of a step-off at the junction of stented and native bronchial wall were also verified.

In some cases, two overlapping stents were used to treat a single lesion. Placement of multiple stents at a single site simplifies accurate lesion coverage because the first stent provides a fixed position marker within the bronchus that can be visualized with both bronchoscopy and fluoroscopy.

CASE REPORTS

Clinical data and information regarding stent placements, failures, and interventions for each patient are summarized in Tables 1 and 2.

Patient 1.—A 54-year-old woman underwent right lung transplantation in September 1995 for severe emphysema. Bronchomalacia in the region of the anastomosis was identified at bronchoscopy performed during work-up of recurrent airway infection. The patient was treated with endobronchial placement of metallic stents in February 1997. The right mainstem bronchus diameter adjacent to the transplant anastomosis was 12 mm. Two 3-cm Palmaz stents (P308) (Johnson & Johnson Interventional Systems, Warren, NJ) were placed across the anastomosis and dilated sequentially with 12-mm and 14-mm angioplasty balloons. Sixteen days

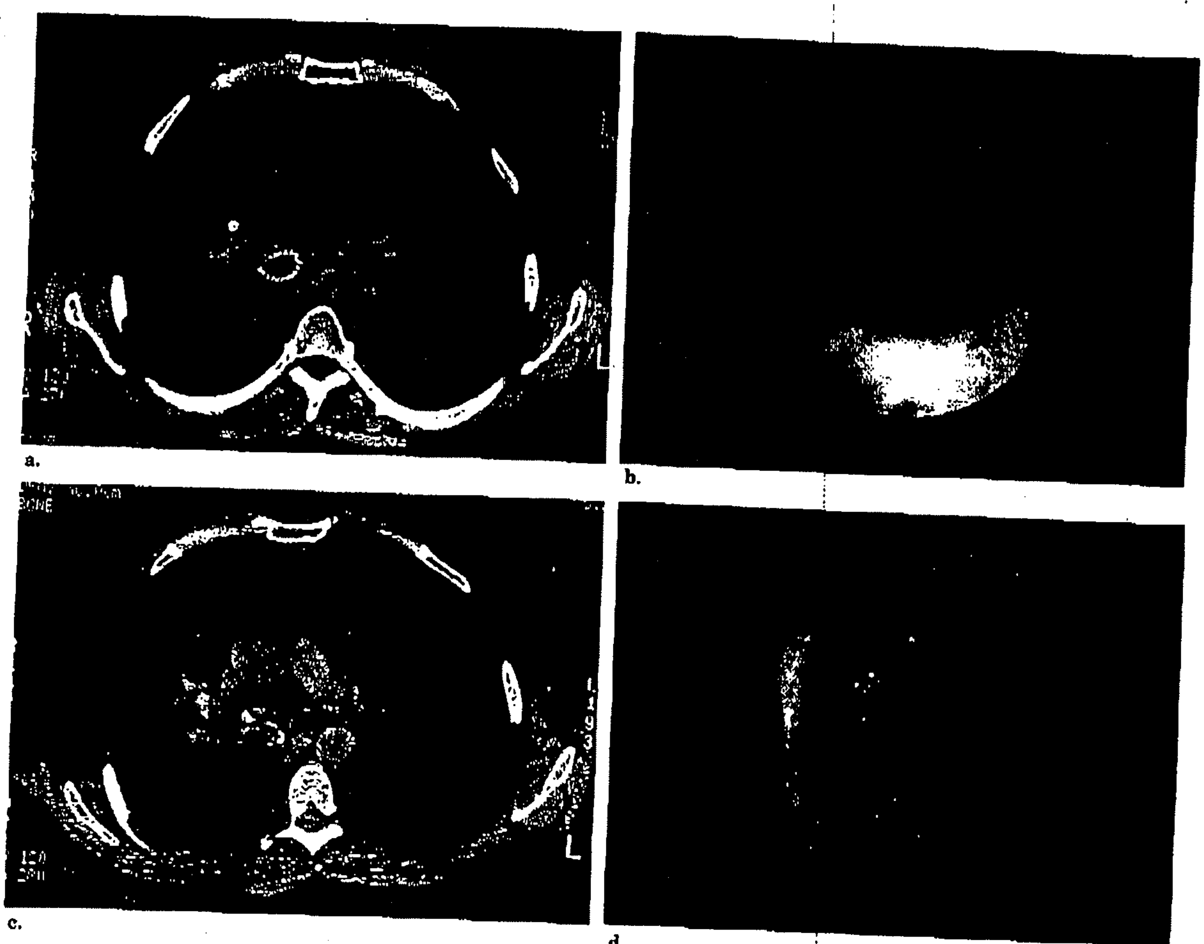


Figure 1. CT (a) and bronchoscopic images (b) of patient 1 44 days after placement of two Palmaz stents in the right mainstem bronchus. (a) CT image at the level of the right upper lobe bronchus demonstrates wide patency of the stented right mainstem bronchus. (b) Bronchoscopic image demonstrates superior aspect of the right mainstem bronchus Palmaz stent just distal to the carina. The stent is widely patent. CT (c) and bronchoscopic (d) images of patient 1 219 days after placement of Palmaz stents in the right mainstem bronchus. (c) CT image at the same level depicted in (a) reveals distortion and collapse of the previously placed stents. (d) Bronchoscopic image at the carina demonstrates partial occlusion of the right mainstem bronchus caused by the collapsed stents.

after the initial procedure, an additional Palmaz stent (P308) was placed in the bronchus intermedius. The diameter of the bronchus intermedius was 11 mm and the stent was expanded with a 12-mm balloon. At this time, a third Palmaz stent (P308) was placed in the right mainstem bronchus to extend the previously stented region. It was dilated sequential to 14 mm. There were no immediate complications attributable to the stent placements. Wide patency of the stented right mainstem bronchus was demonstrated on routine CT and bronchoscopic examinations 44 days after the initial stent placements (**Fig 1a, 1b**). The examinations were performed during both inspiration and expiration. Covering of the right middle lobe orifice resulting from a 0.5-cm displacement of the previously placed bronchus intermedius stent was identified at this time. A tip-deflecting wire was used to hook and remove this stent under bronchoscopic guidance 6 days later. A new, 15-mm-long Palmaz stent (P154) was positioned in the bronchus intermedius and dilated to 12 mm. A second, 20-mm-long Palmaz stent (P204) was then placed coaxially through the first to extend the stented region. The migration of the bronchus intermedius stent was clinically occult. The patient had remained without evidence of recurrent pulmonary infection since the initial stent placements. CT of the chest was performed 219 days after the initial stent placements when the patient again presented with airway infection. Crumpling of the stents within the right mainstem bronchus was identified at this time. The failure was subsequently confirmed at bronchoscopy (**Fig 1c, 1d**). Removal was attempted, but unsuccessful despite

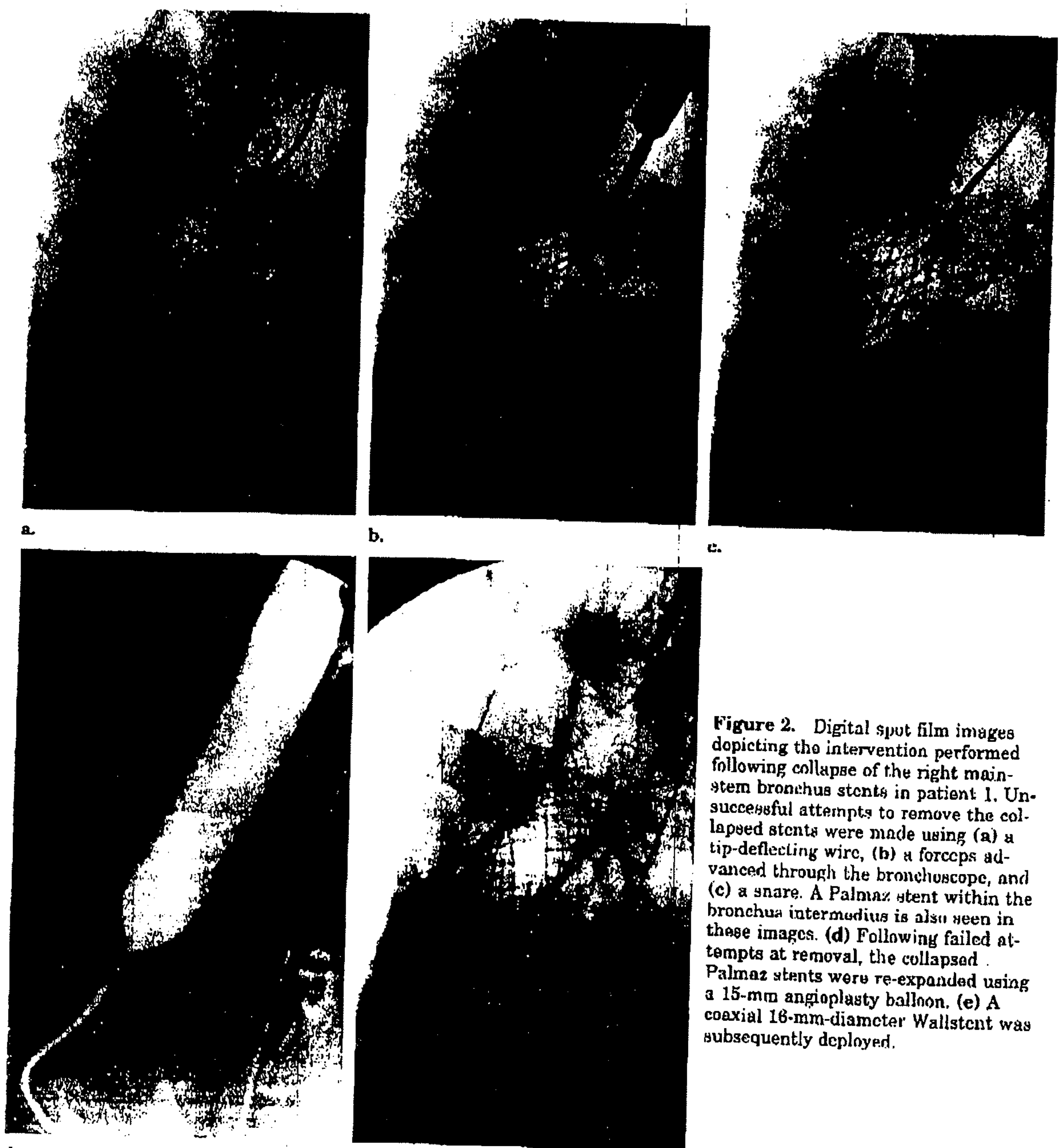
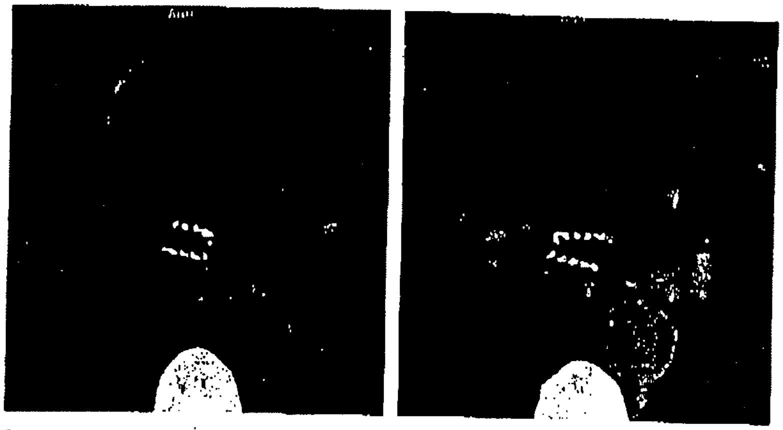


Figure 2. Digital spot film images depicting the intervention performed following collapse of the right mainstem bronchus stents in patient 1. Unsuccessful attempts to remove the collapsed stents were made using **(a)** a tip-deflecting wire, **(b)** a forceps advanced through the bronchoscope, and **(c)** a snare. A Palmaz stent within the bronchus intermedius is also seen in these images. **(d)** Following failed attempts at removal, the collapsed Palmaz stents were re-expanded using a 15-mm angioplasty balloon. **(e)** A coaxial 16-mm-diameter Wallstent was subsequently deployed.

efforts using a tip-deflecting wire (**Fig 2a**), a forceps advanced through the bronchoscope (**Fig 2b**), and a snare (**Fig 2c**). The crumpled stents were subsequently reexpanded using a 15-mm angioplasty balloon (**Fig 2d**). In an effort to prevent recurrent failure of the Palmaz stents, a 16-mm-diameter Wallstent (B16609110) (Schneider, Minneapolis, MN) was deployed and dilated to 15 mm after it was manually trimmed to 2 cm in length (**Fig 2e**). At last follow-up, 14 months after the initial stent placements, the patient was doing well without clinical recurrence of pulmonary infection or need for further intervention.

Patient 2.—A 62-year-old man underwent left lung transplantation in April 1992 for severe emphysema. In October 1996, bronchoscopy revealed a respiratory fluctuation in airway diameter at the transplant anastomo-



a. b.

Figure 3. (a, b) Contiguous 3-mm CT images of patient 3 at the level of the carina. The images were acquired 1 day after placement of a 15-mm-long Palmaz stent in the left mainstem bronchus. The stent was dilated to 8 mm at the time of placement. It appears widely patent and well positioned.

sis suggesting airway malacia. The patient reported a progressive worsening of his exercise tolerance associated with productive cough, wheezing, and blood-tinged sputum approximately 2 months later. In January 1997, two 30-mm Palmaz stents (P308) were placed within the left mainstem bronchus using fiberoptic bronchoscopy and fluoroscopic guidance. The left mainstem bronchus adjacent to the anastomosis measured 8 mm. The stents were sequentially dilated with use of 8-mm and 10-mm balloons. Bronchoscopy immediately following the stent placements demonstrated good stent position and an improvement in the diameter of the bronchial lumen. The patient reported mild cough but experienced subjective improvement in exhalation 1 day after the procedure. Bronchoscopy 18 days later revealed an intact stent. Chest CT was performed 78 days after the initial stent placements when the patient again complained of shortness of breath. Recurrent narrowing in the region of the left mainstem bronchus was identified. Crushing and deformation of the previously placed Palmaz stents were revealed on subsequent bronchoscopy. The stents also appeared to have shortened both proximally and distally. The following day, two additional P308 Palmaz stents were placed coaxially and dilated with use of a 12-mm angioplasty balloon. The patient's recurrent shortness of breath was relieved by this intervention. Bronchoscopy 106 days after the initial stent placements revealed ideal position and diameter of the stents. At last follow-up, 15 months after the initial stent placements, the patient had not experienced a recurrence of the symptom of shortness of breath.

Patient 3.—A 55-year-old woman was diagnosed with Wegener granulomatosis in April 1996. Medical therapy was initiated at this time. The patient presented 2 weeks later following 4 days of increasing dyspnea. CT of the chest at this time revealed a focal narrowing of the left mainstem bronchus just below the carina. Bronchoscopy revealed a stenosis secondary to inflammatory granulomas at this site. Three weeks after initial presentation, the patient underwent placement of a 15-mm Palmaz stent (P154) in the left mainstem bronchus. The right mainstem bronchus and adjacent normal left mainstem bronchus measured 7 mm in diameter on the preprocedure CT scan. These airway sizes were confirmed by measurement of their air bronchograms at the time of the procedure. Based on these measurements, the stent was expanded with an 8-mm balloon. The patient experienced improvement in subjective symptoms and oxygen saturation. Chest CT performed 1 day after stent placement revealed a widely patent stent in the region of the previous left mainstem stenosis. Re-establishment of a normal diameter airway lumen within the stented segment was evident on these images (**Fig 3a, 3b**). Chest CT performed 211 days after placement of the left mainstem bronchus stent revealed its spontaneous migration into the bronchus intermedius (**Fig 3c, 3d**). This finding was not recognized at the time of initial interpretation of this CT examination. Instead, the finding was assumed to represent interval removal of the left mainstem bronchus stent and placement of a new stent in the bronchus intermedius. Preservation of the left mainstem bronchus diameter and maintenance of stent patency despite its translocation into the bronchus intermedius likely contributed to this erroneous interpretation. Crumpling and further displacement of the stent into the right lower lobe bronchus was identified at chest CT performed 357 days after the initial stent placement (**Fig 3e, 3f**). This finding was confirmed on bronchoscopy 5 days later. At the time of bronchoscopy, the crumpled stent (**Fig 4**) was successfully engaged and removed using a basket. At 24 months after initial stent placement, the patient was doing well and had not experienced recurrent increasing dyspnea.

DISCUSSION

Tracheobronchial placement of expandable and self-expanding metal stents represents an appealing therapeutic option for a select group of patients with airway narrowing or malacia. When expanded within airways, these metallic stents can provide a generous lumen relative to the outside stent diameter. The large interstices of these mesh-like tubes permit continued function of respiratory mucosa and may reduce the risk of obstructing covered branch airways (5).

Reports exist, however, of mechanical failures of expandable and self-expanding metal stents following their placement in the tracheobronchial tree. In a series of 36 cancer patient undergoing tracheobronchial Gianturco stent placement, Carrasco et al reported five instances of mechanical stent failure including stent strut fracture (one case), stent unraveling (two cases), and failure of stent expansion (two cases) (1). Hramiec and

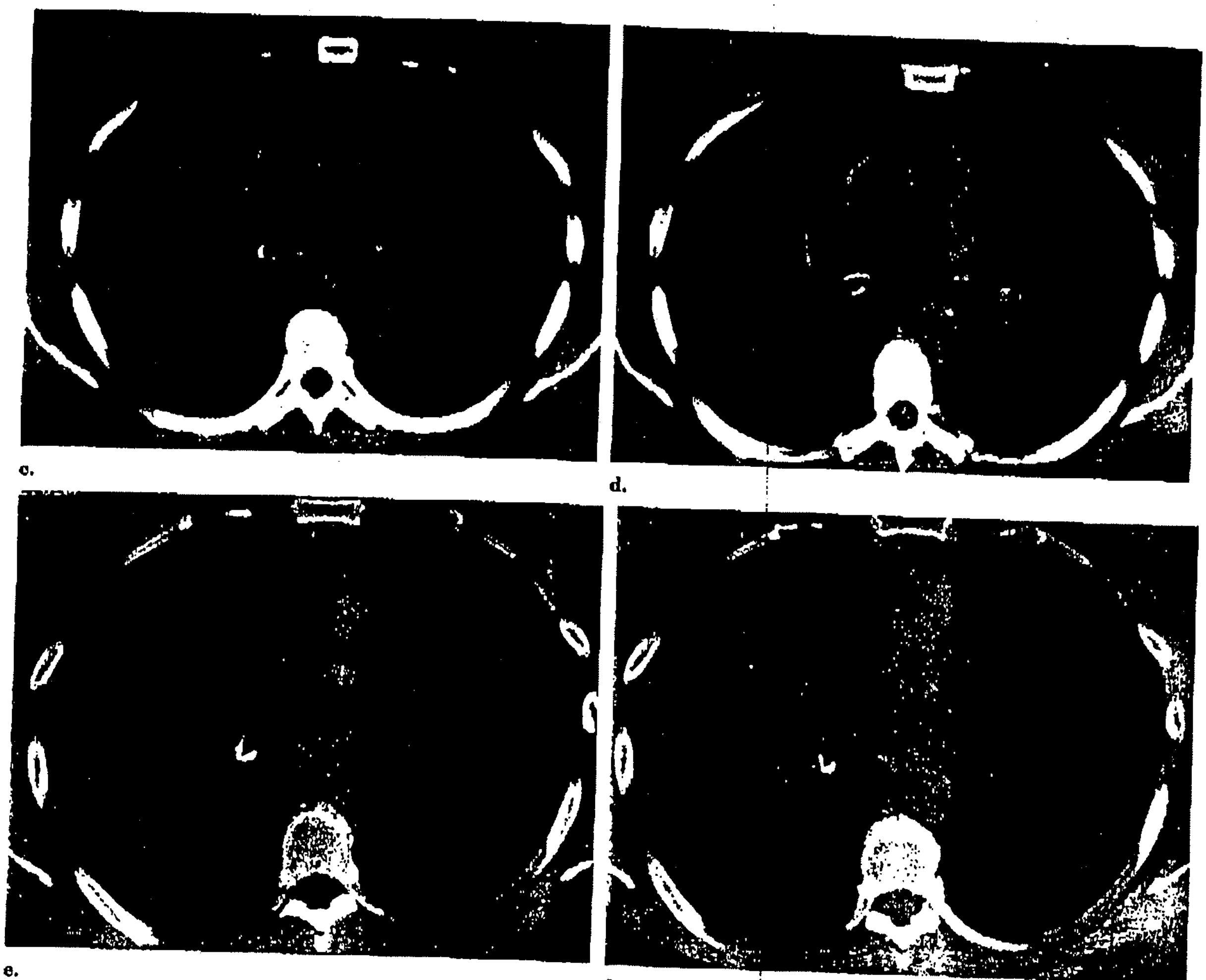


Figure 3. (c, d) Contiguous 7-mm CT images of the same patient 211 days after left mainstem bronchus stent placement. Interval displacement of the stent into the bronchus intermedius is evident. Despite its change in position, the stent remains patent although its lumen diameter is decreased. (e, f) Contiguous 3-mm CT images of the thorax 146 days after the examination pictured in Figure 3b. Further distal migration of the stent into the right lower lobe bronchus is seen. The Palmaz stent has become distorted and its lumen is collapsed.

Hassler reported mechanical failures of three tracheobronchial Gianturco stents. Fracture of metal struts occurred in two of these stents. Widening of the upper end of a third stent was identified, indicating disruption of the nylon suture encircling the end of the stent (4). Fracture of Gianturco stent struts, with or without stent migration, was seen in six of 19 (31%) patients with tracheobronchomalacia in a series reported by Rousseau et al. Two of these six patients underwent stent extraction, and there was one case of fatal respiratory distress (6).

Hind and Donnelly reported a single case of Gianturco stent disruption and dislocation that resulted from entanglement of the stent with a tracheobronchial suction catheter (15).

Mechanical failures of Palmaz stents placed within the tracheobronchial tree have been published. Hautmann et al reported physical distortion of a tracheobronchial Palmaz stent with blockage by accumulated purulent secretions. In this case, the stent was removed and replaced with a Strecker stent (14). Compression and deformation of tracheobronchial Palmaz stents were identified 2 days after placement in one of 12 cases reported by Slonim et al. Those authors attributed the failure to the dynamic, pulsatile character of the extrinsic airway compression, which was caused by an aortic aneurysm (8). Fragmentation of the wire filaments of Wallstents following placement in the tracheobronchial tree has also been cited (4).

These mechanical failures generate uncertainty regarding which of the available metal stents is appropriate for use within the tracheobronchial

Figure 4. Collapsed and distorted 15-mm Palmaz stent following retrieval from the bronchus intermedius of patient 3 (white bar equals 1 cm).

tree. Although the majority of reported mechanical failures involve Gianturco stents, this may in part reflect greater experience with this stent.

Several characteristics of Palmaz stents make them desirable for placement within the tracheobronchial tree. First, placement with balloon expansion facilitates accurate positioning compared with self-expanding stents. Second, they are available in a variety of sizes and, if necessary, can be over-expanded or tapered to conform to a segment of the bronchial tree. Finally, the rigidity of Palmaz stents suggests the potential to provide a significant radial force following expansion. Unfortunately, the longitudinal stiffness and lack of radial compliance of Palmaz stents is also permissive of the deformation and collapse we have observed. When compressed by an impulsive force or bent along their longitudinal axis, Palmaz stents do not recoil to their original expanded configuration. In contrast, Wallstents tend to spring back to their original diameter following compression.

We have observed the deformation and collapse of expandable Palmaz stents following placement within the airways of three different patients. In one of these patients (patient 1), stent failures occurred twice: once in the bronchus intermedius and subsequently in the right mainstem bronchus. Two of our patients were treated with stents for airway malacia. The indication for stent placement in the third patient was stenosis secondary to inflammatory granulomas. The stent failures were, therefore, not associated with a single diagnosis. No dynamic, pulsatile, extrinsic mass was present in any of our patients. None of our patients were treated with tracheobronchial suction in the interval between stent placement and failure. We speculate that the stent failures resulted from the compressive force on airways caused by coughing, which generates high intrathoracic and transmural airway pressures.

In two of our patients (patients 1 and 3), stent migration was also identified. Patient 3 experienced spontaneous migration of a stent from the left mainstem bronchus into the bronchus intermedius. Although the lumen of the stent remained patent despite this translocation, a decrease in stent diameter was seen. Compression and decreased diameter of the stents with resultant loosening probably permitted these migrations to occur.

In conclusion, we have seen deformation and migration of Palmaz stents following placement in the tracheobronchial tree. These stent failures occurred in three of eight patients in whom Palmaz stents were placed. Interventional radiologists should be aware of these potential complications. We believe that stent collapse and migration could result in death secondary to airway obstruction. Because of this experience we have decided to stop using Palmaz stents in the tracheobronchial tree. Although mechanical failure of Wallstents in the form of filament fragmentation is known to occur, resultant clinical complication or loss of stent function has not been reported. Because of their longitudinal flexibility and radial recoil following compression, Wallstents, Strecker stents, or other stents with an intrinsic expansile quality may represent a better choice for placement in the tracheobronchial tree.

References

1. Carrasco CH, Nesbitt JC, Charnsangavej C, et al. Management of tracheal and bronchial stenoses with the Gianturco stent. Ann Thorac Surg 1994; 58:1012–1017.
2. Egan AM, Dennis C, Flower CDR. Expandable metal stents for tracheobronchial obstruction 1994; Clin Radiol 49:162–165.
3. Filler RM, Forte V, Fraga JC, Matute J. The use of expandable metallic airway stents for tracheobronchial obstruction in children. J Pediatr Surg 1995; 30:1050–1056.
4. Hramiec JE, Haasler GB. Tracheal wire stent complications in malacia: implications of position and design. Ann Thorac Surg 1997; 63:209–213.
5. Nashef SAM, Dromer C, Velly JF, Labrousse L, Couraud L. Expanding wire stents in benign tracheobronchial disease: indications and complications. Ann Thorac Surg 1992; 54:937–940.
6. Rousseau H, Dahan M, Lauque D, et al. Self-expandable prostheses in the tracheobronchial tree. Radiology 1993; 188:199–203.
7. Santoro G, Picardo S, Testa G, et al. Balloon-expandable metallic stents in the management of tracheomalacia in neonates. J Thorac Cardiovasc Surg 1995; 110:1145–1148.
8. Slonim SM, Razavi M, Kee S, Semba CP, Dake MD. Transbronchial Palmaz stent placement for tracheobronchial stenosis. JVIR 1998; 9:153–160.
9. Carre P, Rousseau H, Lombart L, et al. Balloon dilatation and self-expanding metal Wallstent insertion for management of bronchostenosis following lung transplantation. Chest 1994; 105:343–348.
10. Brichon PY, Blanc-Jouvan F, Rousseau H, et al. Endovascular stents for bronchial stentosis after lung transplantaion. Transpl Proc 1992; 24:2656–2659.
11. Grillo HC. Management of tracheal tumors. Am J Surg 1982; 143:697–700.
12. Maiwand MO. Cryotherapy for advanced carcinoma of the trachea and bronchi. BMJ 1986; 293:181–182.
13. Dumon JF, Reboud E, Garbe L, Aucomte F, Meric B. Treatment of tracheobronchial lesions by laser photoresection. Chest 1982; 81:278–284.
14. Hautmann H, Huber RM. Stent flexibility: an essential feature in the treatment of dynamic airway collapse. Eur Respir J 1996; 9:609–611.
15. Hind CRK, Donnelly RJ. Expandable metal stents for tracheal obstruction: permanent or temporary? A cautionary tale. Thorax 1992; 47:757–758.